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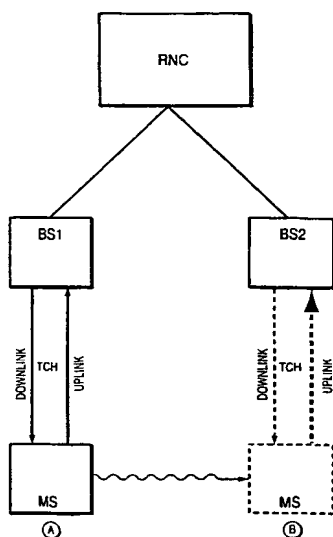
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(54) Title: **NETWORK-EVALUATED HANDOVER ASSISTED BY BOTH MOBILE AND BASE-STATIONS**



(57) **Abstract:** A telecommunications system as described wherein handovers are determined and specified based on both uplink and downlink conditions between a mobile radio and a neighboring cell case station. The mobile radio reports downlink conditions for neighboring cells to a network which instructs the neighboring cell base station to report an uplink condition from the mobile station. The network report handover specifications and mobile station power level based on the uplink and downlink condition information.

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**NETWORK-EVALUATED HANDOVER ASSISTED**  
**BY BOTH MOBILE AND BASE-STATIONS**

**FIELD OF THE INVENTION**

5           The present invention relates to wireless communication systems, and more particularly, to a method and apparatus for efficiently handing over mobile radios among neighboring cells.

**BACKGROUND AND SUMMARY OF THE INVENTION**

10           In a typical cellular radio system, a geographical area is divided into cell areas served by base stations which are connected to a radio network. Each user (mobile subscriber) in the cellular radio system is provided with a portable, pocket, hand-held, or car mounted mobile station which communicates voice and/or data

15           with the mobile network. Each base station includes a plurality of channel units including a transmitter, a receiver, and a controller and may be equipped an omni-directional antenna for transmitting equally in all directions or with directional antennas, each

20           directional antenna serving a particular sector cell. Each mobile station also includes a transmitter, a receiver, a controller, and a user interface and is identified by a specific mobile station

identifier. The first public mobile radio systems were introduced in the late 1970's and early 1980's. As a group, those now well-known systems were referred to as "first generation" systems. They included the "Advanced Mobile Phone System" (AMPS) in the United States, "Nordiskt MobilTelefon-system" (NMT) in Scandinavia, "Total Access Communications System" (TACS) in Britain, and "Nippon Mobile Telephone System" (NAMTS) in Japan. They had certain transmission characteristics that were generally common to all, such as analog frequency modulation at the radio and digital control at the network. Otherwise, however, each system used a communication standard unique to itself in comparison to the others.

In traditional analog cellular systems, when a mobile station is idle, (not using a traffic channel), it tunes to and continuously monitors a control channel corresponding to its current cell in the network. As a result, the mobile can continuously determine whether a page message addressed to it has been received over a control channel. If so, the mobile then transmits a page response over the control channel to the base station which forwards the page response to the radio network. Upon receiving the page response, the radio network selects an available voice channel in the cell from which the page response was received and requests the base station in that cell to order the mobile station via the control channel to establish a through connection.

In addition, a mobile station may access the network to initiate a call by dialing the telephone number and pressing the "SEND" button on the telephone handset. A control signal including the mobile station identifier and the dialed telephone number is transmitted over the control channel to the base station and forwarded to the radio network which validates the mobile station, assigns a traffic channel, and establishes a through connection.

If a mobile station moves between cells while a connection is established, a "handover" of that connection takes place between the cells. The handover can occur as a result of a variety of changes that can occur in the communications between a mobile station and a network. One common handover occurs when the mobile station is in communication with a single base station servicing a cell in which the mobile station resides. As the mobile station commutes from that cell into a new cell serviced by a new base station, the first base station hands over the communication to the new base station. In this way, the mobile station ends communication with a first base station and begins communication with a second base station as it moves from cells serviced by the respective base stations.

In another type of handover, a mobile station may be receiving redundant communication from multiple base stations to ensure quality of transmission. For example, in Figure 1, a radio network core 100 receives a communication 102 from a network

(not shown). The communication 102 is intended to be directed to mobile station MS via an established traffic channel TCH for the communication. The radio network core 100 delivers the communication 102 to a diversity handoff DHO entity 101, which  
5 splits the signal 102 into redundant messages destined for base station BS1 and base station BS2. Base stations BS1 and BS2 deliver the communication via the same traffic channel TCH to the mobile station MS. A variety of techniques are known for providing the diversity handoff described above. Because the  
10 mobile station receives the message via redundant communications over traffic channel TCH, it is able to improve the quality of reception (and conversely, transmission) by opportunistically selecting the signal from the traffic channels or by combining the signals received on the traffic channel in  
15 accordance with known protocols.

As the mobile station moves from point A to point B, the quality of transmission and reception to/from Base Stations BS1 and BS2 changes. Mobile station MS and current Base Stations BS1 and BS2 may, at some point in the communication, benefit  
20 from the addition of Base Station BS3 in the diverse communication scheme. That is, the mobile station MS may be said to be in communication with a current group of Base Stations (BS1 and BS2) and has available neighboring Base Stations (BS3) as future communication link prospects.

In the process of moving from point A to point B, Base Station 2 maintains communication with the mobile station MS during its entire travel and Base Stations BS1 and BS3 may or may not remain in communication depending upon signal quality. In Figure 1, the mobile station is communicating using the traffic channel TCH, regardless of the base stations to which it is communicating.

The mobile station maintains a record of its current Base Stations, and may test (or be instructed to test) neighboring cells for inclusion in that record. As conditions dictate, Base Stations in current communication are added to or removed from the current record.

A handoff can also occur even within the confines of a single base station, as shown in Figure 2. There, a base station is shown having four antennas A1-A4 defining four geographical service areas. The mobile station MS at position A communicates with the base station BS over traffic channel TCH. At position A, the mobile station communicates with the base station over redundant reception/ transmissions to antennas A1 and A4. After moving to position B, however, mobile station MS may begin transmitting/receiving to antennas A1 and A2. As the mobile station moves from point A to point B, a handoff occurs as between antennas A1/A4 and antennas A1/A2.

The benefit of diversity reception/splitting, as shown in Figures 1 and 2, is that communications between a base station

and a mobile station (in the case of Figure 2) and a radio network core and a mobile station (as in the case of Figure 1) are never broken. That is, in the case of Figure 1, mobile station MS always remains in communication with radio network core via base station 2, even as it moves from point A to point B and even as it may be handed off from Base Station 1 to Base Station 3. Similarly, in the case of Figure 2, mobile station MS remains in communication with antenna A1 as it moves from point A to point B, even though it may be handed off from antenna A4 to antenna A2.

The handoff scenario occurs as a result of the existence of defined conditions, such as signal strength between the mobile station and the receptor. In the case of Figure 1, for example, as the mobile station moves (as depicted throughout the figures by the wavy line) from point A to point B, a determination may be made that signal strength as between mobile station MS and Base Station BS3 makes communication with BS3 preferable to communication with BS1. In prior handoff scenarios, either the mobile station MS or the base station (BS1-BS3) measured the current radio conditions between the mobile station and the neighboring cells (often measured and reported by the MS) and the resource conditions (finding free channels in the cell pointed out by the MS measurements). In typical today, the MS measures the cell conditions and reports the results to the network which the evaluates the handover in light of the required resources. This created problems, however, in that conditions which precipitated a

handoff from the network's perspective may not have precipitated a handoff from the mobile station's perspective. That is, a network may desire a handoff as a result of signal conditions, but the mobile station may regard the handoff conditions differently, and vice-a-versa. If the network made the handoff determination, it would do so without regard to the mobile station conditions. On the other hand, if the mobile station made the handover determination, it did so without regard to the network conditions.

In the present invention, both uplink and downlink signals to/from the mobile radio and the radio network are involved in a handover evaluation. The invention is particularly useful whenever the uplink and downlink conditions are different in one network or when the mobile station is near the border of two different network operators. In such a case, handover related measurement reports from a mobile station may be delivered to the radio network and used by the network to determine when the base station should measure the quality of an uplink transmission from the mobile station. Both measurements are used to make the handoff determination.

The invention allows the BS to take some measurements upon the MS in parallel with the MS measurements on the BS. Also, some BSs listen to the uplink without sending anything on the downlink other than to use the existing downlinks from other BSs to transfer power control commands.



The invention also permits the network to correct channel and/or power level uplink conditions before a radio hands over to a new cell broadcast area.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

5       The foregoing and other objects, features, and advantages of the invention will be apparent from the following description of preferred embodiments as well as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout. While individual functional blocks and components  
10 are shown in many of the figures, those skilled in the art will appreciate that these functions may be performed by individual hardware circuits, by a suitably programmed digital microprocessor, by an application specific integrated circuit (ASIC), and/or by one or more digital signaling processors  
15 (DSPs).

FIGURE 1 is a schematic diagram of a simplified mobile radio communication system;

FIGURE 2 is a schematic diagram of a simplified mobile station to base station communication system;

20       FIGURE 3 is a schematic representation of a mobile station to base station communication link;

FIGURE 4 is a schematic representation of a simplified mobile station communication network;

FIGURE 5 is a schematic representation of a simplified radio network controller connected to a and base station ;

FIGURE 6 is a schematic representation of a simplified mobile station;

5       FIGURE 7 is a graphical representation of the current set and neighbor set thresholds employed by an example embodiment of the present invention;

FIGURE 8 is a schematic representation of a simplified mobile communications system in which mobile stations  
10       communicate to different base stations for uplinks and for downlinks; and

FIGURE 9 is a schematic representation of an example embodiment of the present invention in use across borders between different operators.

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### **DETAILED DESCRIPTION OF THE DRAWINGS**

In the following description, for purposes of explanation and not limitation, specific details are set forth, such as particular embodiments, data flows, signaling implementations, protocols,  
20       techniques, etc., in order to provide an understanding of the present invention. However, it will be apparent to one skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other

instances, detailed descriptions of well-known methods, interfaces, devices, and signaling techniques are omitted so as not to obscure the description of the present invention with unnecessary detail.

The present invention is described in the non-limiting,  
5 example context of a universal mobile telecommunications  
(UMTS) 10 shown in Fig. 4. A representative, connection-  
oriented, external core network, shown as a cloud 12 may be for  
example the Public Switched Telephone Network (PSTN) and/or  
the Integrated Services Digital Network (ISDN). A representative,  
10 connectionless-oriented external core network shown as a  
cloud 14, may be for example the Internet. Both core networks are  
coupled to corresponding service nodes 16. The PSTN/ISDN  
connection-oriented network 12 is connected to a connection-  
oriented service node shown as a Mobile Switching Center (MSC)  
15 node 18 that provides circuit-switched services. In the existing  
GSM model, the MSC 18 is connected over an interface A to a  
Base Station Subsystem (BSS) 22 which in turn is connected to  
radio base station 23 over interface A'. The Internet  
connectionless-oriented network 14 is connected to a General  
20 Packet Radio Service (GPRS) node 20 tailored to provide packet-  
switched type services sometimes referred to as the serving GPRS  
service node (SGSN). Each of the core network service nodes 18  
and 20 connects to a UMTS Terrestrial Radio Access Network  
(UTRAN) 24 over a radio access network (RAN) interface.  
25 UTRAN 24 includes one or more radio network controllers 26.

Each RNC 26 is connected to a plurality of base stations (BS) 28 and to any other RNCs in the UTRAN 24.

Preferably, radio access is based upon wideband, Code Division Multiple Access (WCDMA) with individual radio  
5 channels allocated using CDMA spreading codes. Of course, other access methods may be employed. WCDMA provides wide bandwidth for multimedia services and other high transmission rate demands as well as robust features like diversity handoff and RAKE receivers to ensure high quality. The mobile stations 30  
10 use transmission codes so base station 28 can identify transmissions from that particular MS 30. In the current WCDMA standard, codes are supposed to be allocated as follows for the dedicated channels:

- a) the uplink and downlink transmission is using  
15 channelization codes, and on top of that a scrambling code;
- b) the channelization code determines e.g., the spreading factor, and the spreading factor determines the maximum bitrate;
- c) mobiles in the same cell using the same frequency and the same spreading factor use different channelizations codes for  
20 the downlink channels but the same scrambling code; and
- d) mobiles in other cells use the same channelization codes but different scrambling codes.

The scrambling codes secure the integrity, between downlink transmissions using the same channelization code but in different cells. The scrambling code used in uplink secure the integrity between uplink transmissions from different mobile stations in the same or in other cell.

Thus, the MS gets its own scrambling code while the BS transmission to a specific mobile on a dedicated channel will use a common scrambling code but a unique channelization code. The MS have the ability to combine a downlink transmission using a different scrambling codes and different channelization codes (one limitation today is that the spreading factor of the channelization codes must be the same from all cells).

The radio network controller 26 and base station 28 shown in Fig. 5 are radio network nodes that each include a corresponding data processing and control unit 32 and 33 for performing numerous radio and data processing operations required to conduct communications between the RNC 26 and the mobile stations 30. Part of the equipment controlled by the base station data processing and control unit 33 includes plural radio transceivers 34 connected to one or more antennas 35. The mobile station 30 shown in Fig. 6 also includes a data processing and control unit 36 for controlling the various operations required by the mobile station. The mobile's data processing and control unit 36 provides control signals as well as data to a radio transceiver 37 connected to an antenna 38. Both the data

processing and control unit 36 and transceiver 37 are powered from voltage supplied by battery 39. The amount of power supplied by the battery 39 to the data processing and control unit 40 and transceiver 37 is regulated by one or more control  
5 signals from the data processing and control unit 36.

The present invention may be employed in the context of the example mobile communications system 10 shown in Fig. 4 in which the radio network controllers 26 and base stations 28 form a radio access network between a core network node (like the  
10 MSC 16) and the mobile stations 30. In prior handover scenarios, the mobile station performed radio condition evaluations and the network performed resource evaluations to determine if a handover should occur. A principal problem that occurs as a result is over- or under-power conditions in which the MS is  
15 broadcasting at too great a signal strength or too little signal strength for the conditions existing in a neighboring hand-over cell. The present invention, on the other hand, allows the network to make measurements in lieu of, or (more likely) in parallel with measurement reports received from the mobile radio before the  
20 network sends the handover command.

Figure 3 illustrates these conditions in more detail. When the mobile station MS is in position A, traffic channel TCH provides an uplink from the mobile station MS to base station BS1 and a downlink from base station BS1 to mobile station MS.  
25 Communication quality between the mobile station and the base

station is defined by reference to both the uplink conditions and the downlink conditions. As the mobile station moves to position B, a handoff determination will have to be made as between Base Station BS1 and Base Station BS2. To ensure high quality  
5 communication, the handoff determination is made by uplink and downlink communication quality between the mobile station and Base Station BS1 in comparison to the mobile station in Base Station BS2.

In particular, if the handoff between Base Station BS1 and  
10 Base Station BS2 is made by the network only, then the network is unsure of the downlink conditions as between Mobile Station MS and Base Station BS1 vis-a-vis Base Station BS2. . The current protocol allows the network to make the resource evaluation regardless of whether the MS or the BS makes the radio condition  
15 evaluation. That is, the MS may report the radio condition information for use by the network in evaluating the handoff or the BS may provide the radio condition evaluation based on the uplink conditions. The radio condition information can be estimated by using pathloss estimates measured by the MS but the information  
20 could be explicitly measured by the BS to be more accurate. .

Referring now to Figures 1-3, the presently preferred embodiment of the present invention has the mobile station reporting to the RNC 100 regarding downlink profiles which the RNC uses to order handoff operations. The MS will use the  
25 BCCH channel to measure upon also for the cells to which it is in

communication with (the cells that are included in the active set).  
At position A, MS maintains a record of current Base Stations to  
which it is in communication. The MS is also continually  
monitoring neighboring cells for quality of downlink signal based  
5 on a reception quality of a common pilot channel. Alternatively,  
any channel containing pilot bits having a constant output power,  
and covering a whole cell can be used for neighboring cell  
measurements. Thus, as MS moves from position A to position B,  
the MS measures the BCH downlink conditions from Base Station  
10 BS3. The MS reports those measurement profiles from the  
downlink to the RNC 100 whenever the profile from a neighboring  
cell exceeds a standard. The RNC informs the base station, such  
as BS3, that an MS has identified the Base Station as a prospective  
Base Station for current or near-term communication. The RNC  
15 100 instructs BS3 to measure uplink transmission power received  
from MS as it moves from position A to position B. If the mobile  
station is transmitting at high power (uplink) as reported by the  
base station and is receiving at high power (downlink) as reported  
by the mobile station at the Base Station BS3 (the neighboring  
20 cell), the RNC 100, using existing links between MS-BS1 and  
MS-BS2, orders the mobile station to lower its power levels to an  
appropriate non-interfering level for the cell defined by BS3. By  
temporarily lowering MS output power, BS3 uplink is protected  
from excessive interference until a radio link is established  
25 between the MS and BS3 with full support for fast power control.



The Base Stations BS1 and BS2 continue communicating with mobile station MS over the transmission channel TCH that has been previously setup. At first, only power control is provided between MS and BS3 until BS3 reports to the RNC 100 that the  
5 uplink from MS is at an appropriate level. At that time, RNC 100 notifies MS that it should setup a handoff to include BS3 in its current communication report on TCH (or if the mobile station capacity can accept no more base stations, to take away the  
10 BS3). Of course, the RNC 100 has informed the mobile station MS to reduce its transmission power to the appropriate level as it includes BS3 in the current report of base stations to which the mobile station is communicating on TCH.

There is also a possibility to let the BS3 receive the uplink  
15 and combine this uplink with BS1 and BS2 long before the BS3 is ordered to start its transmission on the downlink. As a result of combining the uplinks from BS1, 2 and 3 the MS can be instructed to lower its power. This is typically achieved by changing the signal-to-interference ratio target in the BS1 and BS2 since BS1  
20 and BS2 have fast power control connection with the MS on downlink.

In general, the preferred embodiment of the present  
invention removes any links where both the downlink and the uplink are both weak. A mobile station keeps within its active  
25 communication set communications with base stations in which a

strong uplink i.e., low pathloss and low disturbance (factors that makes it possible to use low power to reach the quality goal), is coupled with a weak downlink (or vice versa). Finally, strong uplink and downlink signals will ensure the continuation of  
5 communications between a mobile station and any base station with a possible power reduction instruction being given by RNC to the MS.

According to the example embodiment of this invention, a mobile station reports BCH power levels for all neighboring cells,  
10 whether the signals are weak or strong. The RNC uses the measurements from the mobile station to determine, based on the reported downlink information, when a neighboring base station should measure uplink information transmitted by the mobile station. When the uplink information meets the threshold, a  
15 handoff is triggered. Other reasons for starting BS measurements could also be that a BS suffers from a high interference level, that the MS output power is about to reach its limits, or that a BS member in the active set is running out of power. Another reason could be that the frequency used by the MS is getting overloaded  
20 and the MS must be handed over to another frequency. The BS could then measure upon the MS and evaluate which BS the UE should use after the frequency change assuming that the other frequency is not supported by all cells in an area. When the BS measures on a MS the MS is identified by its unique scrambling  
25 code. As a result of the BS measurement the MS is identified by

its unique scrambling code. And the system should be able to do a much more reliable inter-frequency handover decision.

Figure 7 illustrates a comparison of the signal quality (downlink) received at a mobile station from various base stations as the mobile station moves through geographic regions proximate to BS1, BS2, and BS3 over time. Early in time, the mobile station is in voice communication solely with BS1 (and may be monitoring downlink conditions from BS2 and BS3). Neither BS2 nor BS3 are included in the mobile stations current base station active set. Nevertheless, the mobile station continues to report to the RNC 100 what the downlink signal strengths are for neighboring cells BS2 and BS3. At time t1, the signal strength for the BS2 downlink reaches a threshold for inclusion in the current communication active set, )CS. This can be seen as a request for update. (In IS 95 the request is more explicit, such as "the MS gives the network an offer it cannot refuse").

The mobile station continues to test the downlink signal strength from Base Station BS3. When the downlink signal strength from BS3 exceeds a neighboring cell set threshold )NS, the mobile station reports that BS3 is now a candidate for inclusion in the mobile station current set. For a hard handover, RNC notifies BS3 to evaluate uplink conditions and report on possible interference and power level conditions. RNC reports back to MS when the connection with BS3 can begin and at what power levels. BS3 will then be added to the current report when

the RNC notifies the MS that appropriate handover specifications exist (and appropriate power levels) and MS detects a )CS downlink threshold from BS3. For a soft handover, the MS does not adjust its power explicitly; it adjusts its power when the power control bits that are transferred by the downlink in the active set indicates that the MS power should be decreased.

Figure 8 illustrates another example embodiment in which the present invention provides advantageous application. In Figure 8, mobile station MS1 begins at position A with uplink and downlink communications on TCH from three Base Stations BS1, BS2 and BS3. MS thus has a current communication set equal to BS1, BS2 and BS3. Mobile Station MS1 monitors BCH from BS4 and BS5, eventually adding them to its proposed neighboring cells. Problems exist, however, with adding BS4 and BS5 into the current report. As for BS4, signal strength is too great and should be reduced as quickly as possible. If BS 4 detects a high signal the BS4 could instruct the BS1, 2, 3, to lower their signal-to-interference target and thereby force the MS power down quickly by using fast power control bits so it would not disturb BS4. It would also be beneficial if the BS4 uplink is included in the DHO combining at the same time to compensate for the reduced uplink power of the UE. The BS4 downlink could be started and the MS active set could be updated later on when the network considers it to be appropriate. As for BS5, MS communication on TCH causes unacceptable interference with communications already established between MS2 and BS5 on channel TCHp.

If the mobile station MS1 made the determination to handoff, independently of the network, based solely on a comparison of the downlink signal strengths has between BS1, BS2, BS3 versus BS4 and BS5, the communication would be

5 impeded on the uplink side as the network MS power would overwhelm BS4 and would interfere with existing communications in BS5. On the other hand, according to the preferred embodiment of the present invention, MS1 detects BCH downlinks from BS4 and BS5 as it moves to position B and reports to the network when

10 )NS is exceeded for each neighboring base station. When the threshold is reached, the network does not immediately command the handoff procedure, but signals the base station to make an uplink evaluation. Upon doing so, the Base Station BS4 or BS5 will detect the power level problems or interference conditions and

15 will report the conditions to the network. If BS4 and BS1, 2, 3 are operating on the same frequency, the handover should be considered an early power control that is taking place to penalize this MS to the benefit of all other MSs using BS4. If the MS power is reduced the BS5 may not suffer from this MS anymore.

20 The RNC then awaits further downlink informational input from the mobile station vis-a-vis other neighboring cells.

Figure 9 illustrates yet another example embodiment which makes good use of the present invention. In Figure 9, mobile station is serviced by operator 1 to the left of the border indicated

25 and, once it moves to position B, will be serviced by a different operator, operator 2, to the right of the border. While in cell 1 of

operator 1, the mobile station MS uplinks at frequency F1. If the mobile station moves into cell 2 of operator 2, the mobile station may uplink at frequency F1 in interference with other transmissions. Applying the present invention, a current list is  
5 created by the MS for operator 1 (those base stations that exceed )CS threshold) and a neighbor list for operator 2 ( )NS threshold) by detecting the BCH downlinks of operator 2 cells. This information is reported to the RNC of operator 2 which instructs the base station in cell 2 to measure the uplink from mobile station  
10 MS. This uplink measurement may reveal high signal strength from this specific MS and hence the cell 2 is suffering from interference from this MS as long as the MS is not connected to cell 2. The RNC for operator 2 then reports to the RNC for operator 1 that the neighbor list will not allow mobile station to  
15 uplink at frequency F1 in cell 2. There are at least 3 options to do after receiving that information from operator 2.

1. Make an inter operator handover from cell 1 (operator 1) to cell 2 (operator 2).
2. Make inter frequency handover but stay with operator 1.
- 20 3. Limit the output power.

If an approach according to 1 is chosen, the RNC for operator 1 could request a handover to be performed from cell 1 to cell 2 and RNC operator 2 would order the BS in cell 2 to measure

on the user entity and answer the request for handover based on the measurement results.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

**WHAT IS CLAIMED IS:**

- 1           1. In a telecommunications system having a plurality of  
2   mobile radio stations, a method comprising:  
3           communicating through one of the mobile radios with at  
4   least one current base station;  
5           measuring at the one mobile radio a broadcast channel  
6   downlink characteristic from at least one neighboring base station  
7   and reporting to a network when the characteristic downlink  
8   reaches a defined downlink condition;  
9           measuring at the network a corresponding radio uplink  
10   condition from the one mobile radio to the neighboring base  
11   station;  
12          evaluating free channels of the neighboring base stations to  
13   determine which of said free channels are suitable for said one of  
14   the mobile radios based on the measured downlink characteristic  
15   and the corresponding radio uplink condition;  
16          reporting from the network to the mobile station a handover  
17   event specification and a power level for the mobile station based  
18   on the uplink condition and the downlink condition; and  
19          handing over the one mobile radio to the neighboring base  
20   station in accordance with the handover event specification and  
21   power level.
- 1           2. The method as in claim 1, wherein the handover is a soft  
2   handover.



1           3. The method as in claim 1, wherein the handover is an  
2 inter operator handover.

1           4. The method as in claim 2, wherein the mobile radio  
2 maintains communication with the current base station following  
3 the handover.

1           5. The method as in claim 1, wherein the defined downlink  
2 condition is a first threshold relating to a downlink signal level  
3 between the one mobile radio and the current base station.

1           6. The method as in claim 1, wherein the uplink condition  
2 is a measured quantity from the group consisting of: signal  
3 strength, signal to noise, pathloss, time difference, and roundtrip  
4 delay.

1           7. The method as in claim 5, wherein the uplink condition  
2 is a measured quantity from the group consisting of: signal  
3 strength, signal to noise, pathloss, time difference, and roundtrip  
4 delay.

1           8. A node in a telecommunications system including mobile  
2 radios, comprising:  
3           transceiver circuitry transmitting and receiving 1)  
4 information from a mobile radio regarding a neighboring cell radio  
5 downlink signal condition; 2) information from the neighboring  
6 cell regarding a corresponding radio uplink signal condition  
7 caused by the mobile radio in the neighboring cell, and

8 electronic data processing and control circuitry determining,  
9 based on the downlink signal condition and uplink signal  
10 conditions, a handover event specification including a suitable  
11 communication channel and a power level for the mobile radio,  
12 and communicating the handover event specification to the mobile  
13 radio to precipitate a handover by the mobile radio to the  
14 neighboring cell.

1 9. The method as in claim 8, wherein the handover is a soft  
2 handover.

1 10. The method as in claim 8, wherein the handover is a  
2 hard handover.

1 11. The method as in claim 8, wherein the downlink signal  
2 condition is a first threshold.

1 12. The method as in claim 8, wherein the uplink signal  
2 condition is a measured quantity from the group consisting of:  
3 signal strength, signal to noise, pathloss, time difference, and  
4 roundtrip delay.

1 13. A telecommunications system, comprising:  
2 a mobile radio;  
3 a current base station in communication with the mobile  
4 radio on a traffic channel;  
5 a neighboring base station, the mobile radio monitoring a  
6 broadcast channel of the neighboring base station;

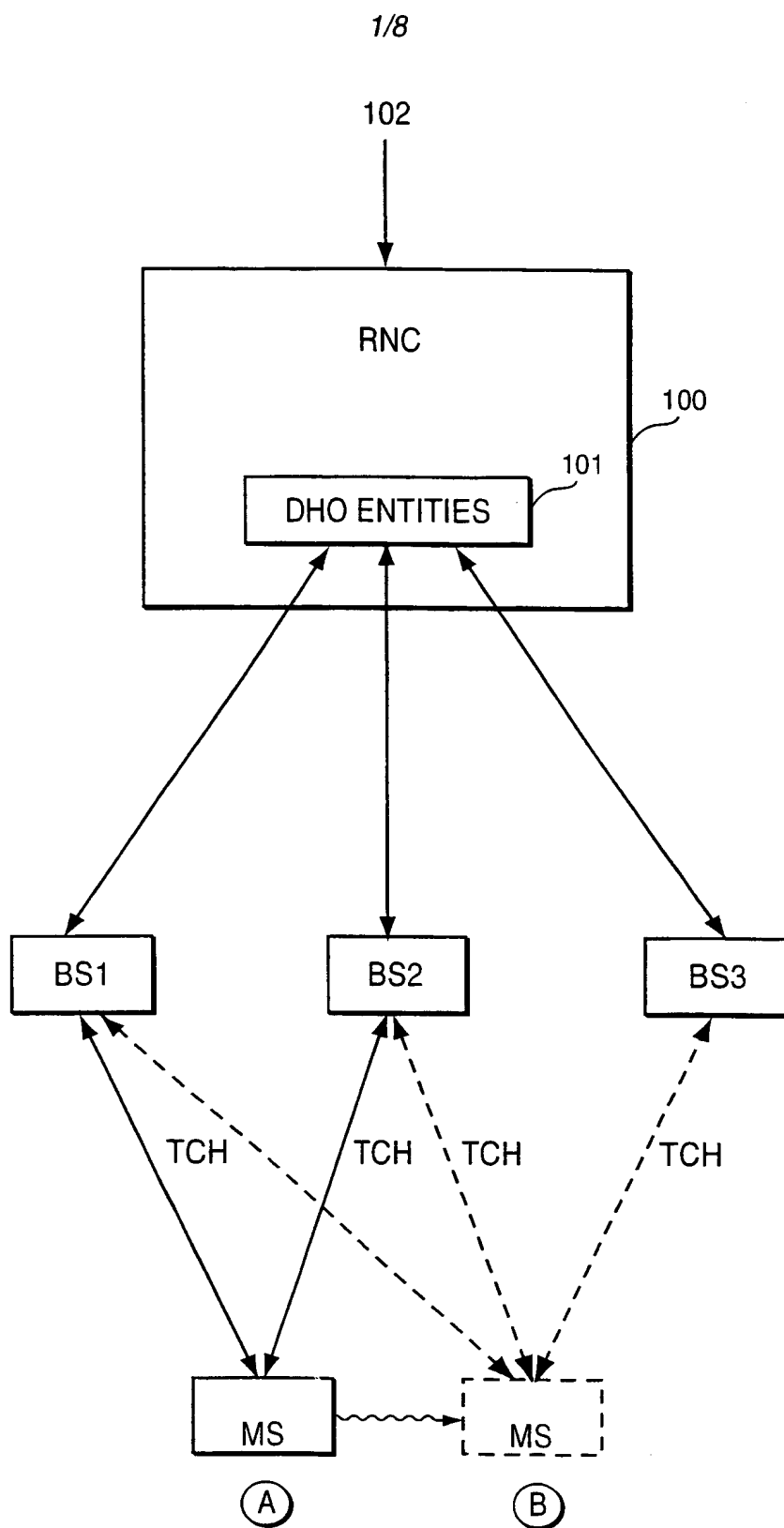
7           a network in communication with the current and  
8   neighboring base stations, the mobile station reporting when the  
9   broadcast channel being monitored reaches a pre-defined  
10   neighboring cell downlink condition, the neighboring cell  
11   reporting a corresponding uplink condition from the mobile radio,  
12   the network including processes to report a handover event  
13   specification and power level determined based on the reported  
14   downlink condition and uplink conditions to the mobile radio to  
15   coordinate a handover for the mobile radio to the neighboring cell.

1           14. A method as in claim 13, wherein the handover is a soft  
2   handover.

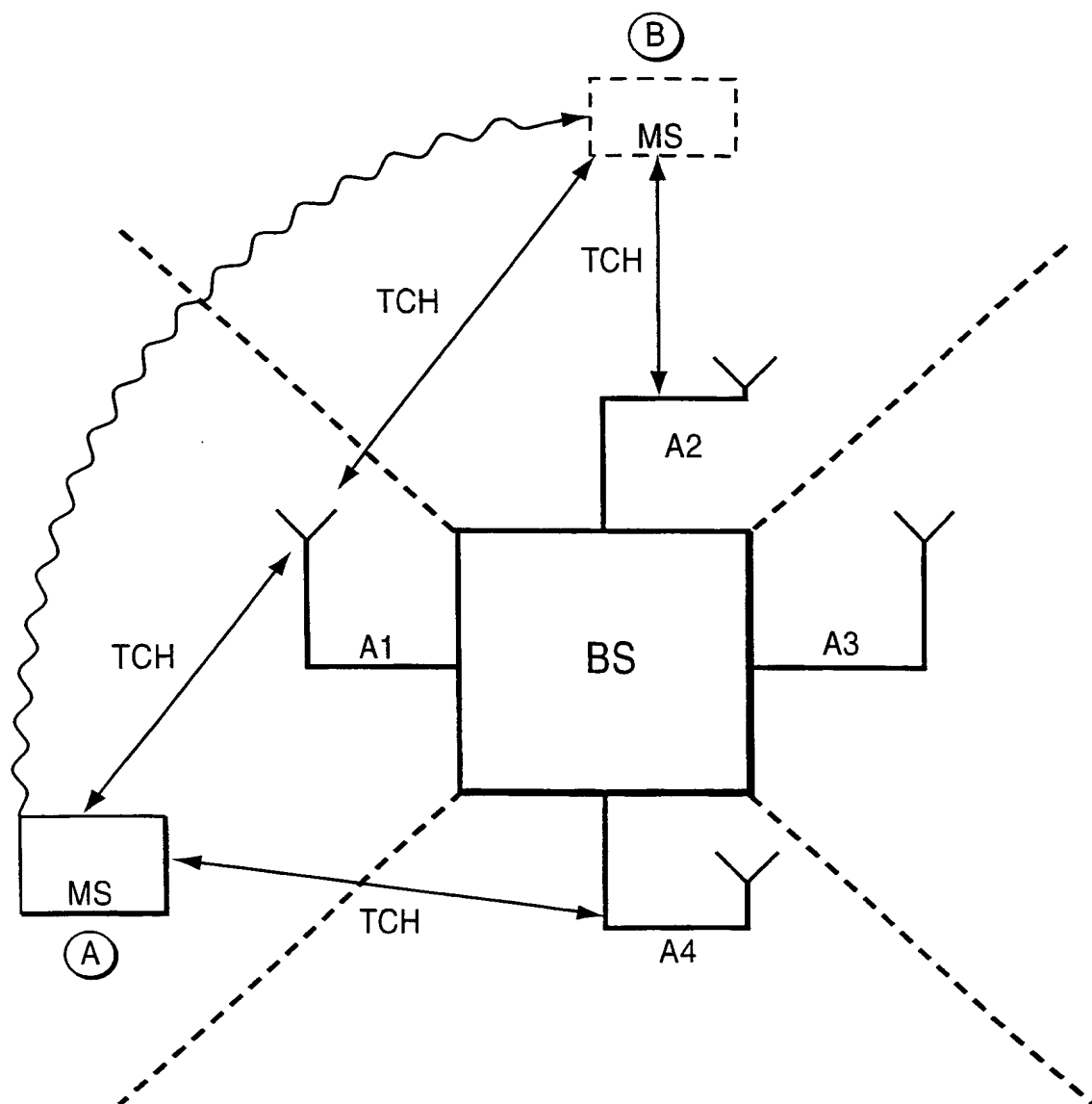
1           15. A method as in claim 13, wherein the handover is a  
2   hard handover.

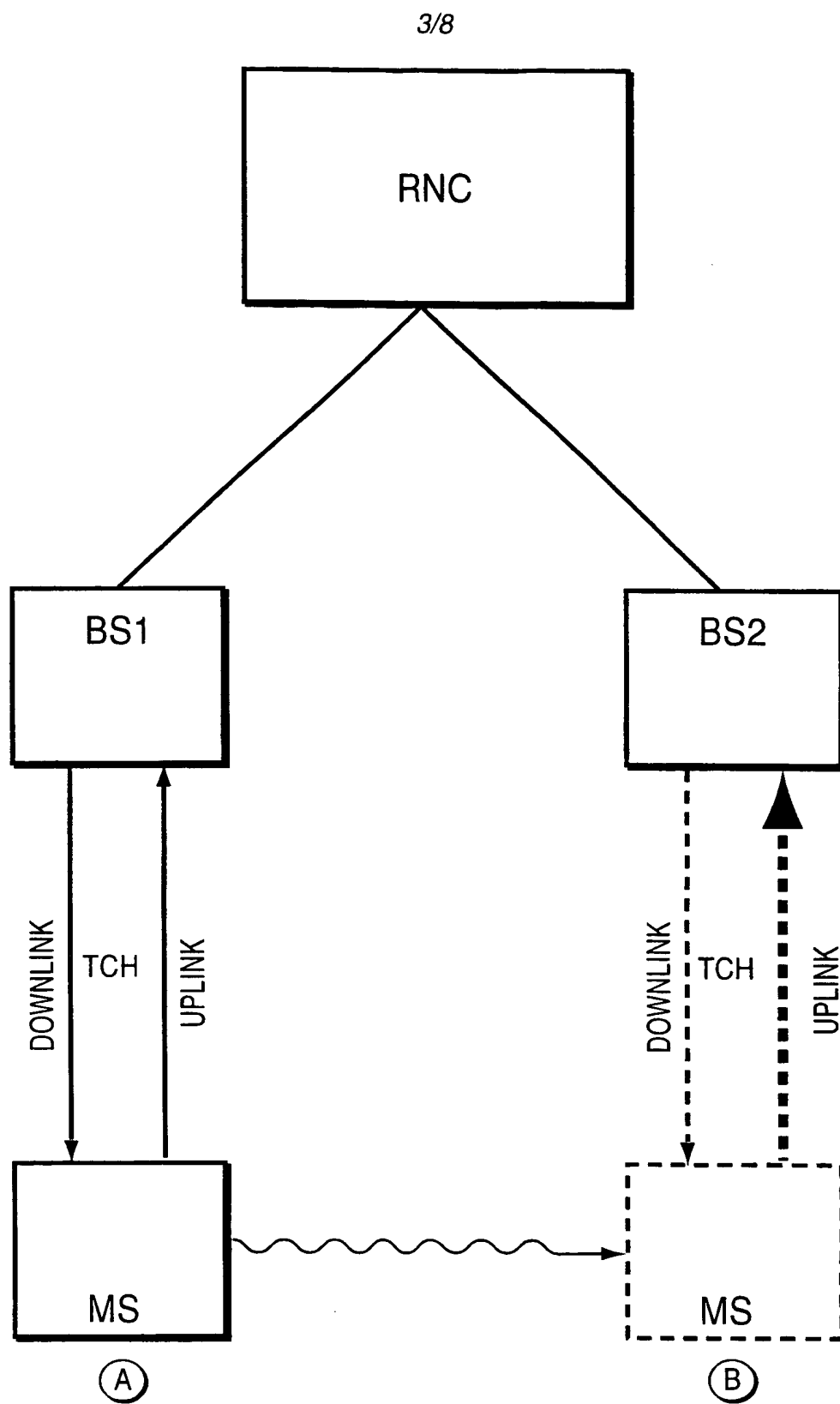
1           16. A method as in claim 13, wherein the downlink  
2   condition is a first threshold.

1           17. A method as in claim 13, wherein the downlink  
2   condition is a measured quantity from the group consisting of:  
3   signal strength, signal to noise, pathloss, time difference, and  
4   roundtrip delay.

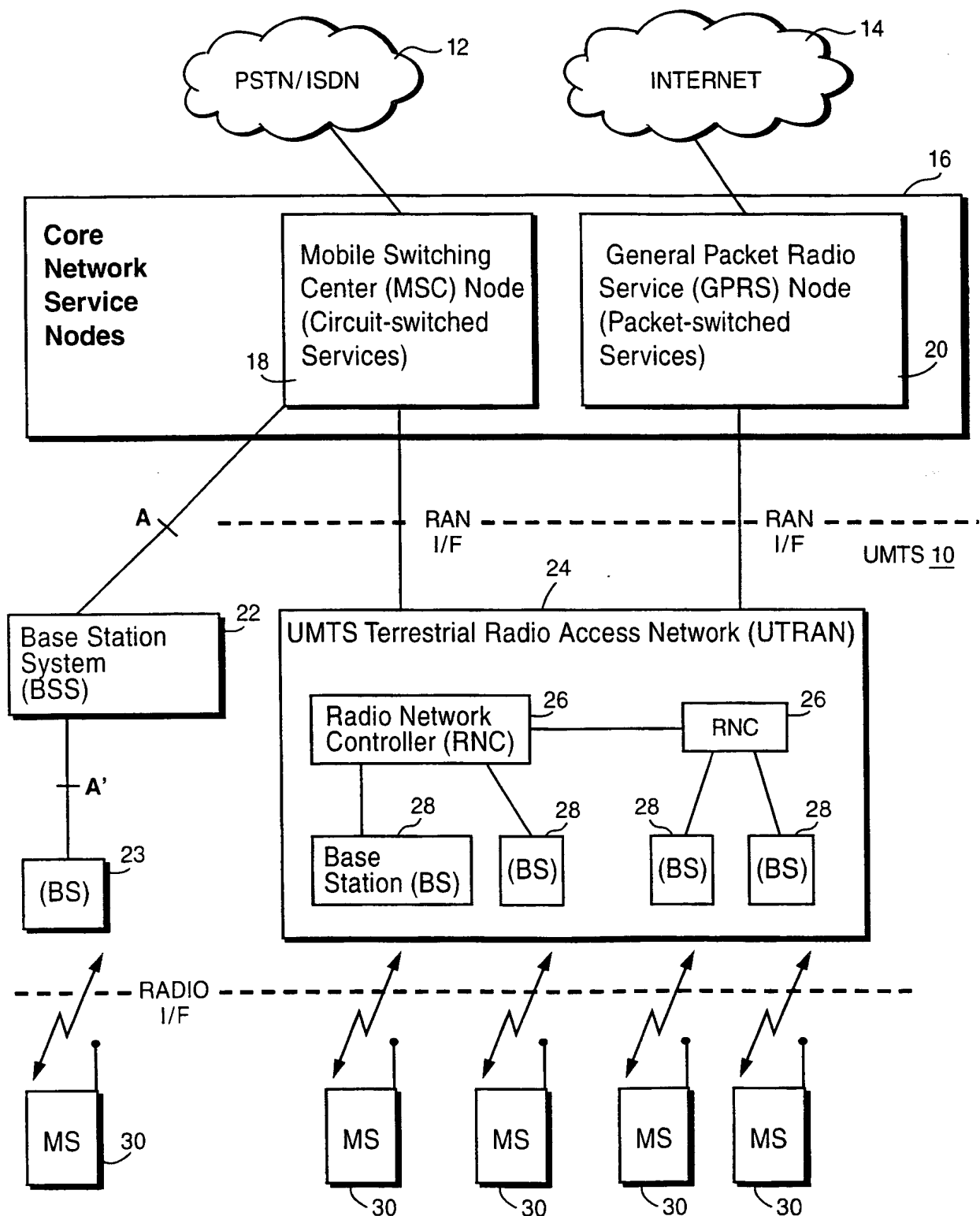
*Fig. 1*

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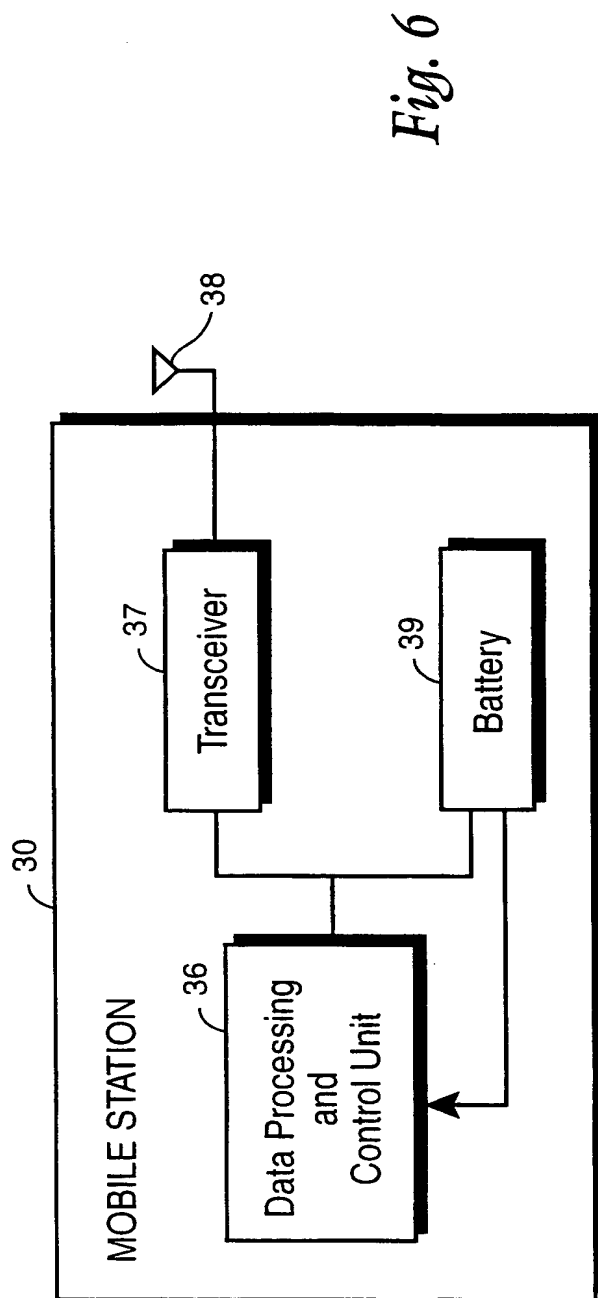
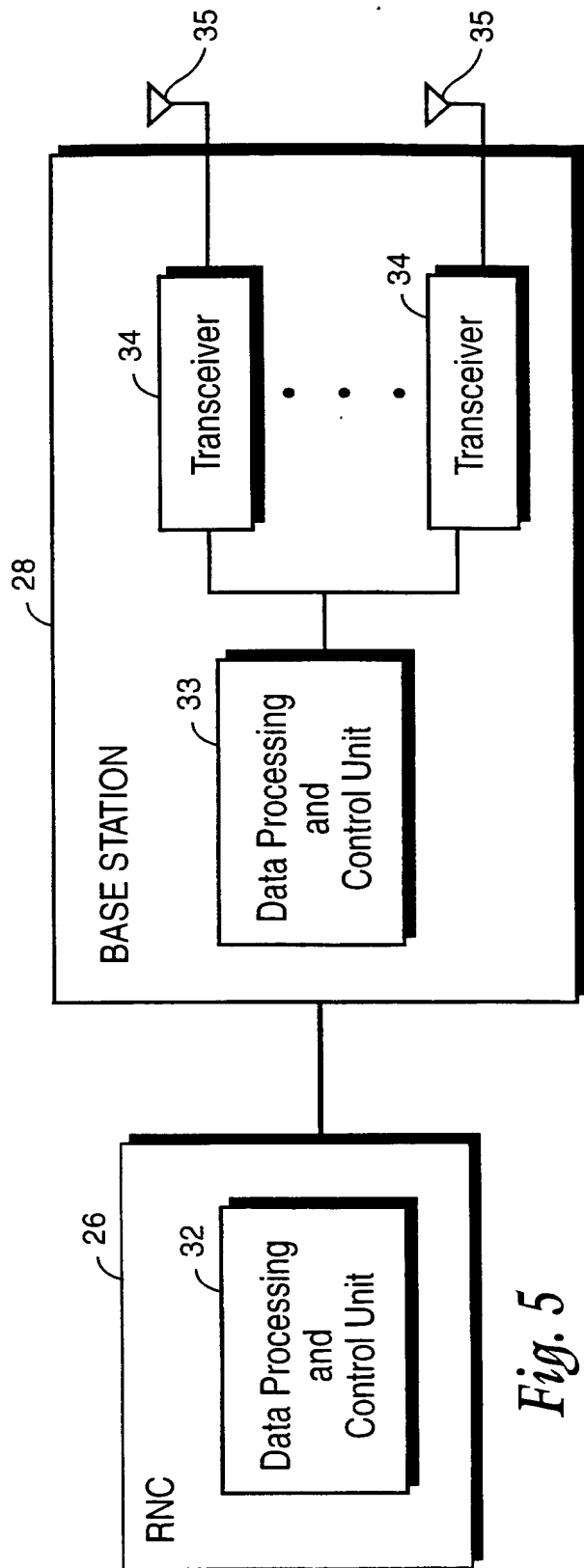
*Fig. 2*

*Fig. 3*

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*Fig. 4*

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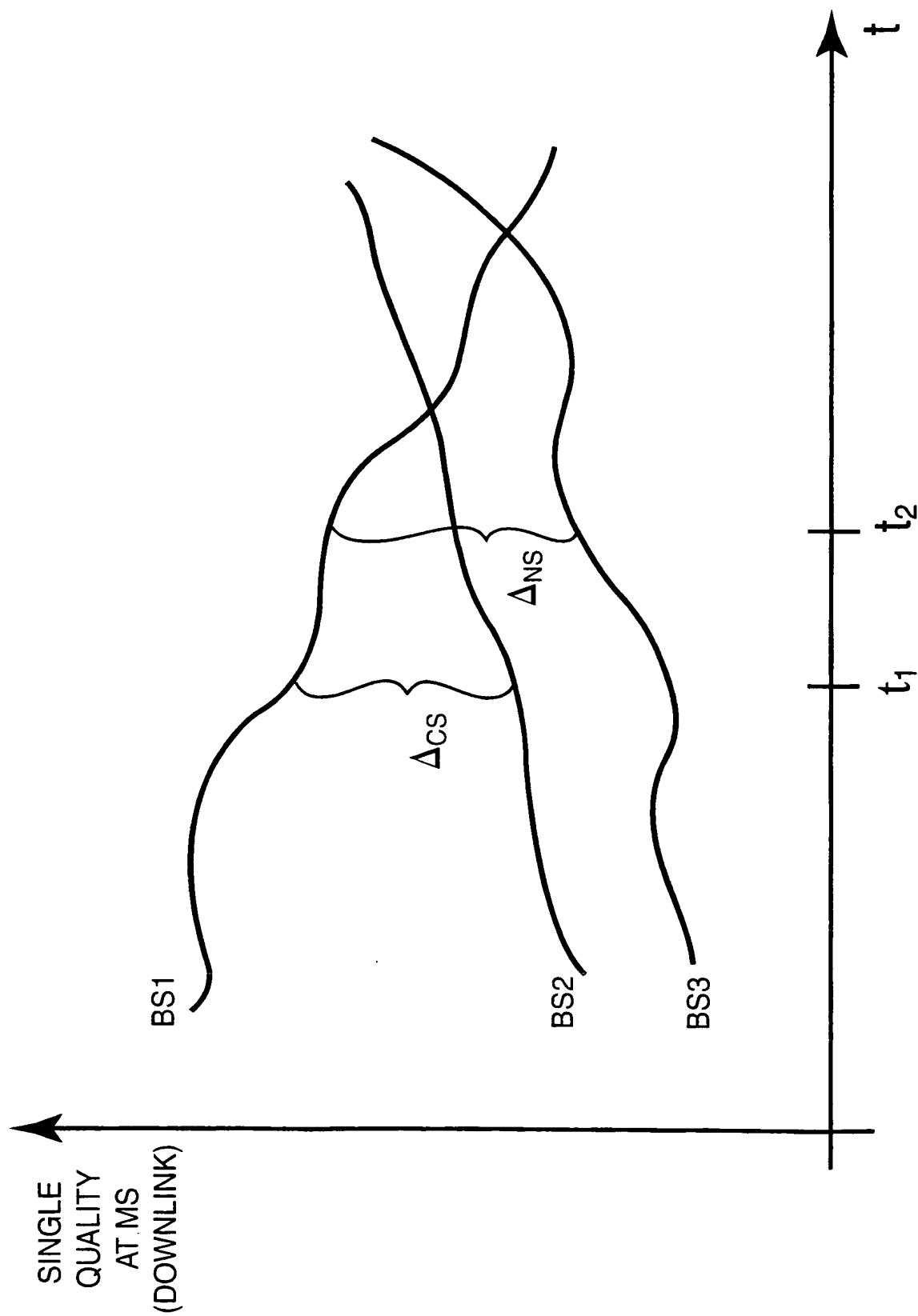
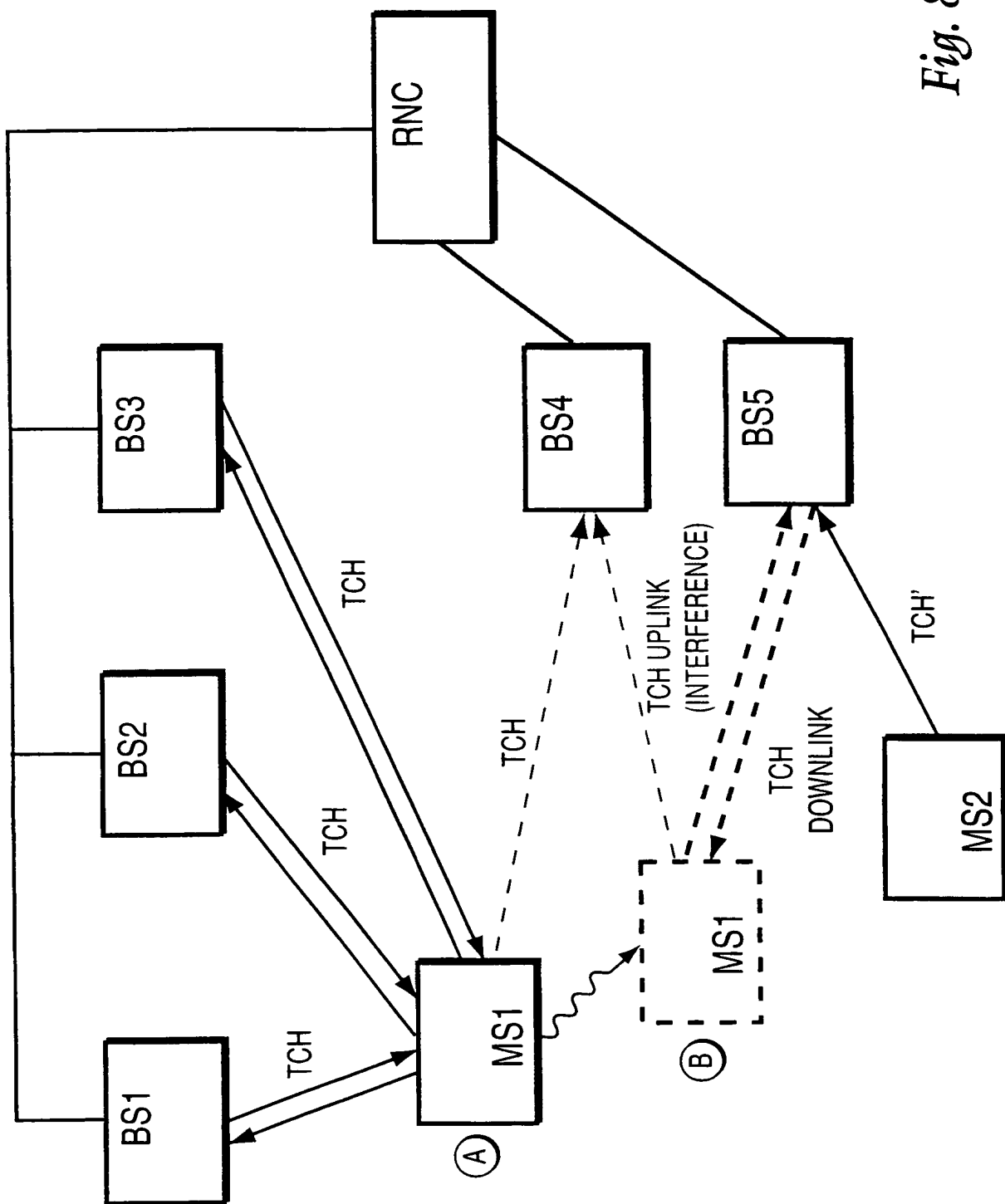


Fig. 7



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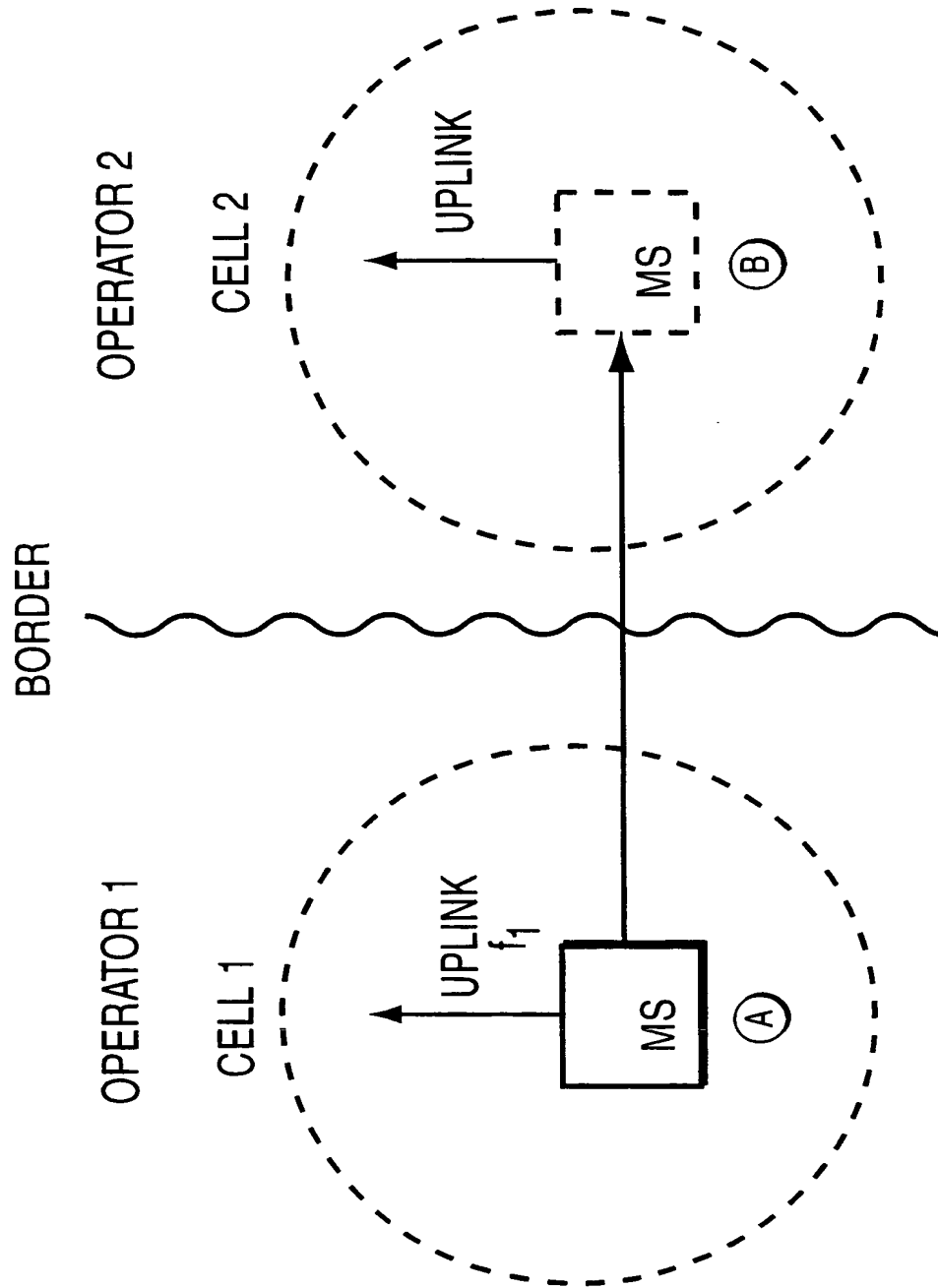


Fig. 9

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/SE 00/01039

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No.       |
|------------|---|-----------------------------|
| X          | US 5 487 174 A (PERSSON BENGT Y)<br>23 January 1996 (1996-01-23)<br><br>column 8, line 34 -column 10, line 48<br>claims 1-4                     | 1,2,4-9,<br>11-14,<br>16,17 |
| A          | US 5 697 055 A (GILHOUSEN KLEIN S ET AL)<br>9 December 1997 (1997-12-09)<br>column 8, line 55 -column 10, line 9<br>claim 1                     | 1-17                        |
| A          | US 5 634 192 A (HANLEY DONALD V ET AL)<br>27 May 1997 (1997-05-27)<br>column 3, line 3 - line 42<br>column 5, line 31 - line 49<br>claims 1,2,8 | 1-17                        |



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search

9 August 2000

Date of mailing of the international search report

16/08/2000

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# INTERNATIONAL SEARCH REPORT

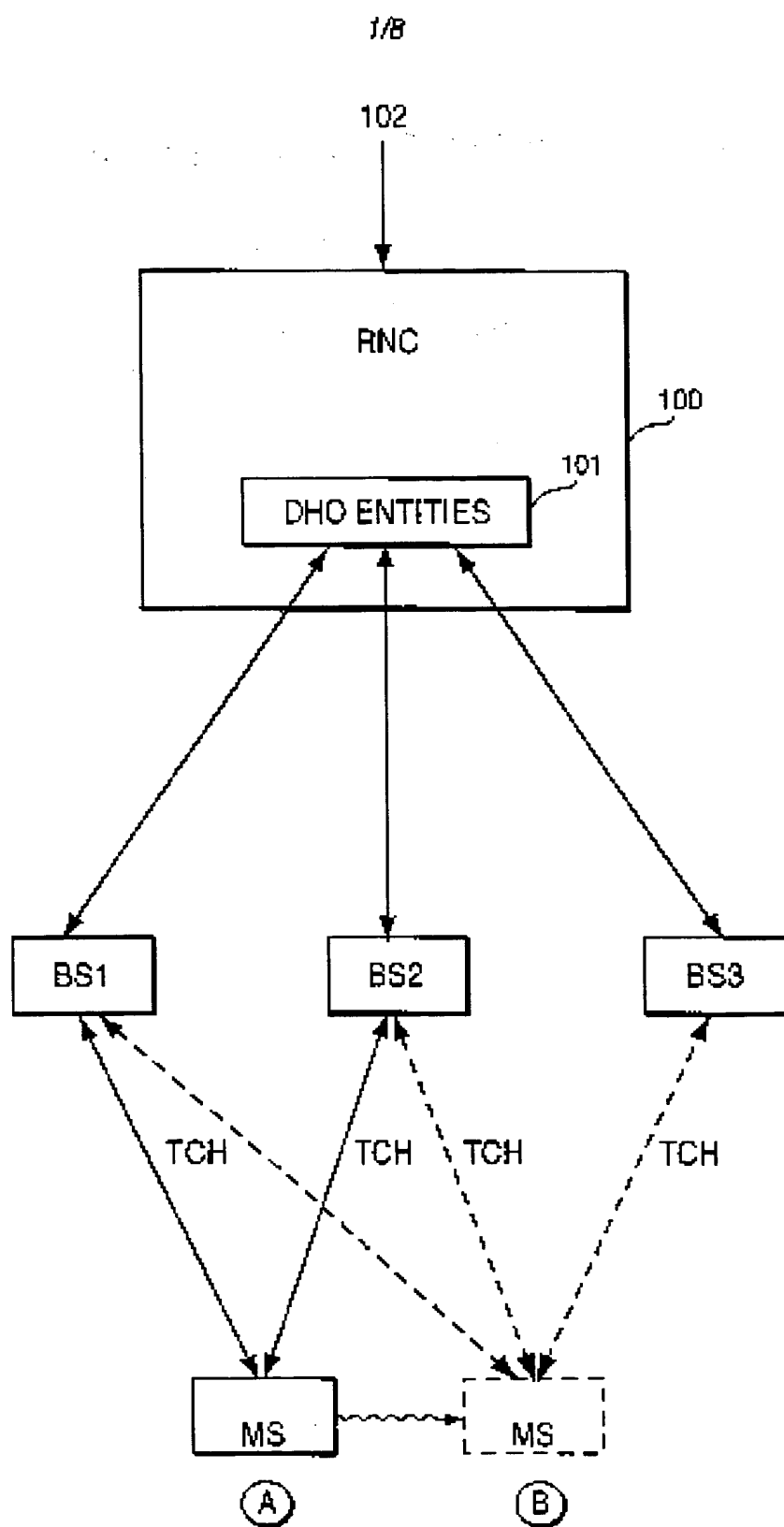
Information on patent family members

International Application No

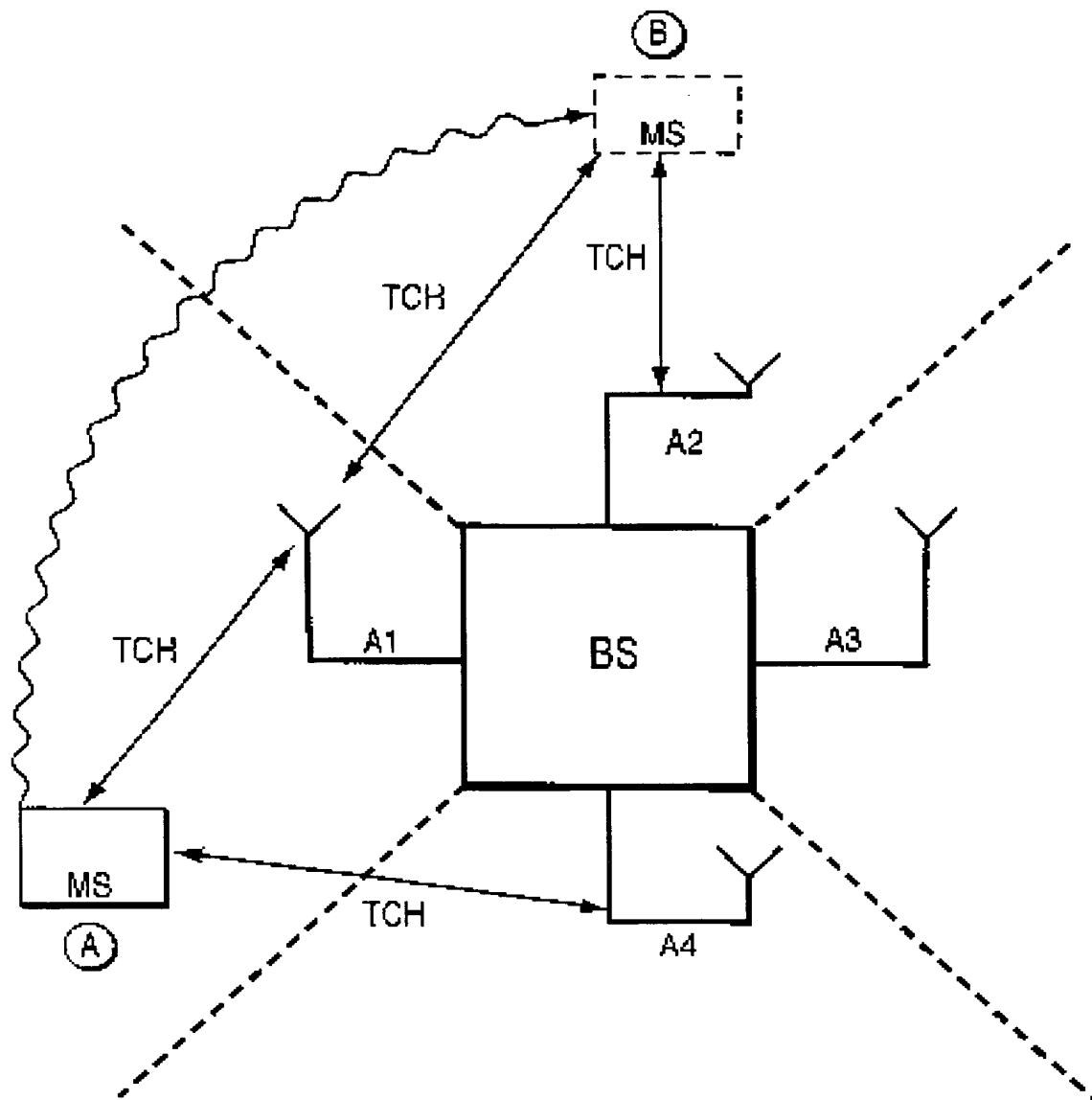
PCT/SE 00/01039

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)   | Publication<br>date  |
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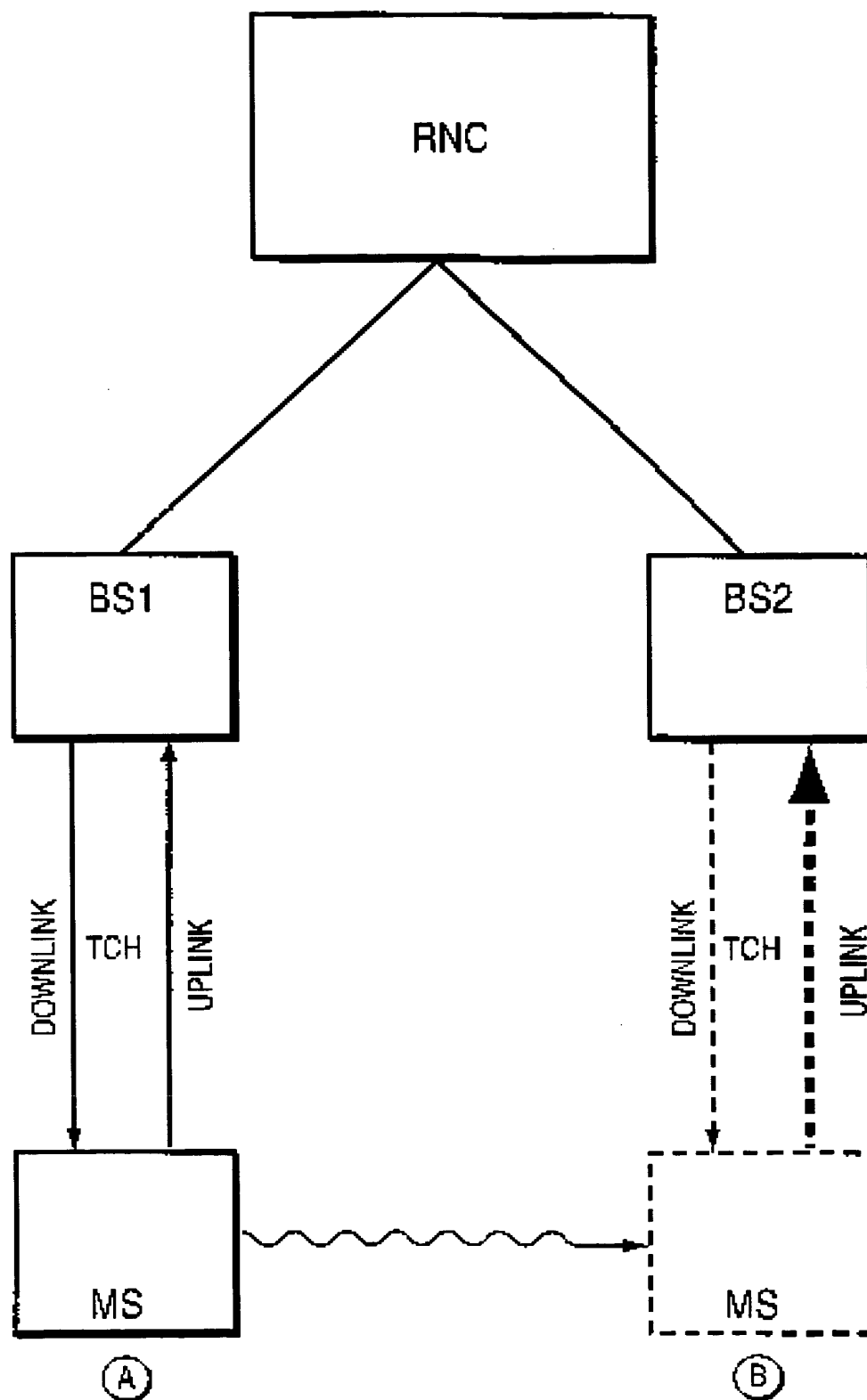
*Fig. 1*

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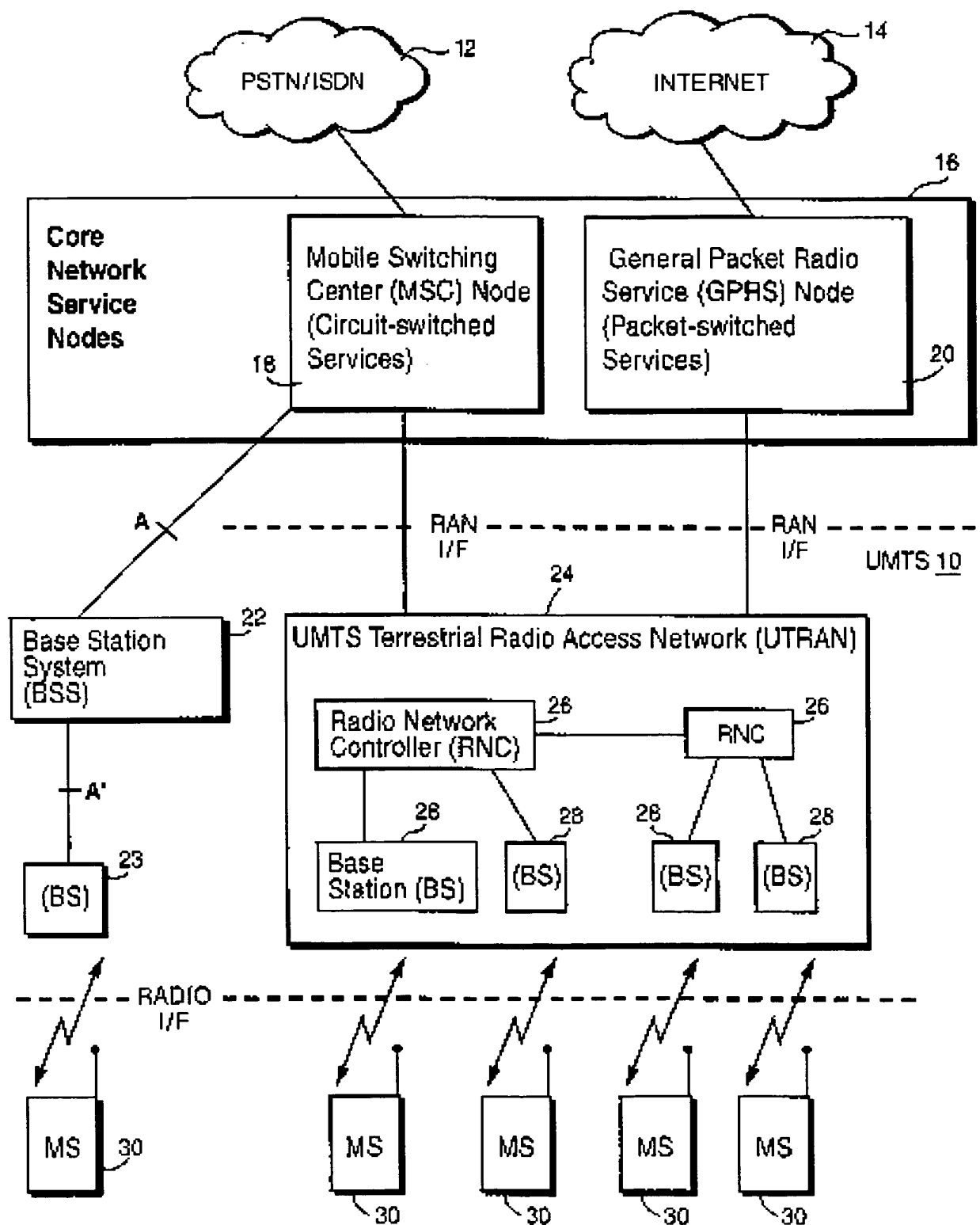
*Fig. 2*



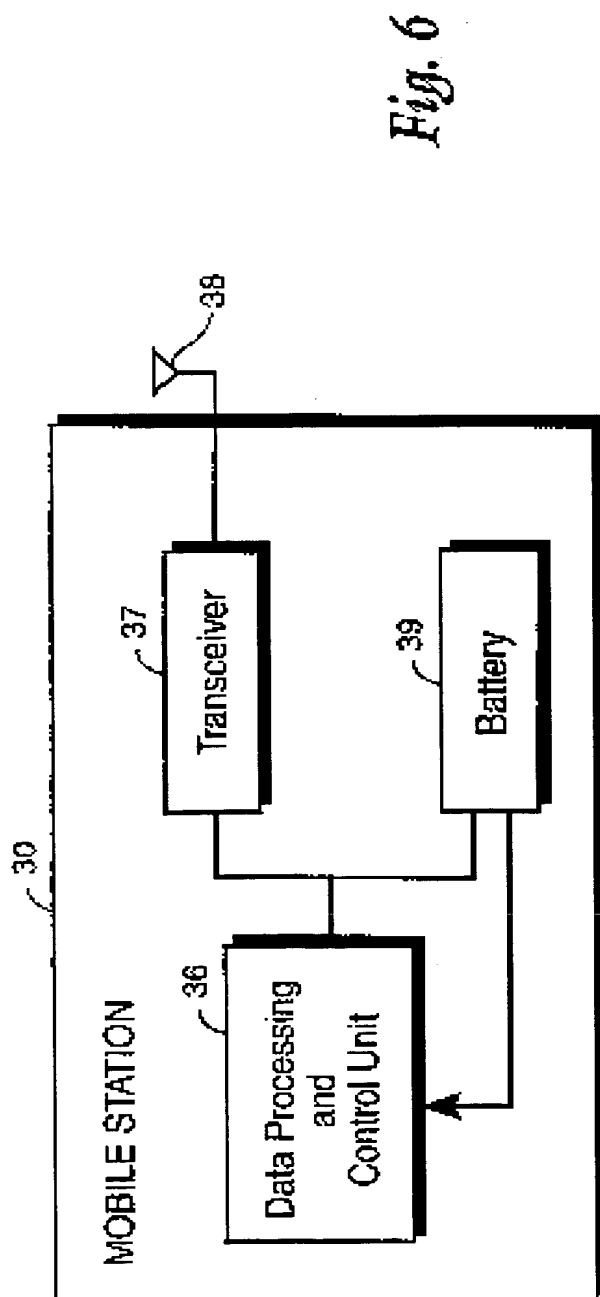
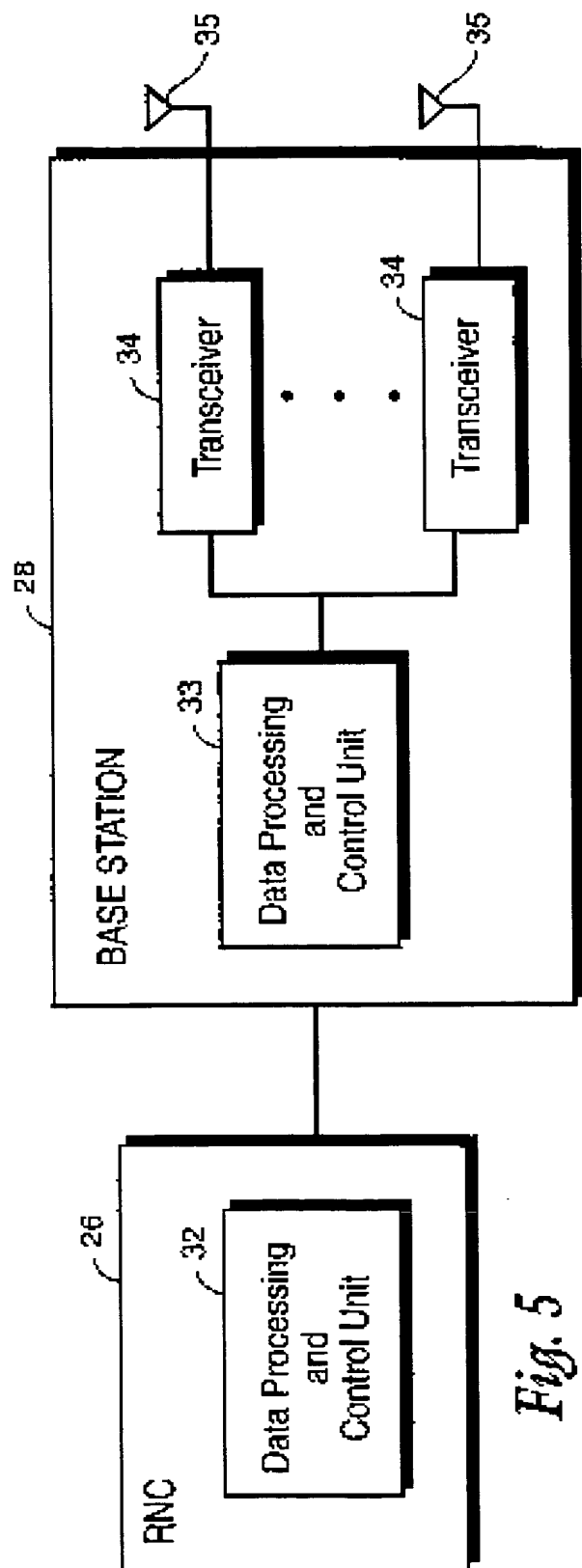
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*Fig. 3*

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*Fig. 4*

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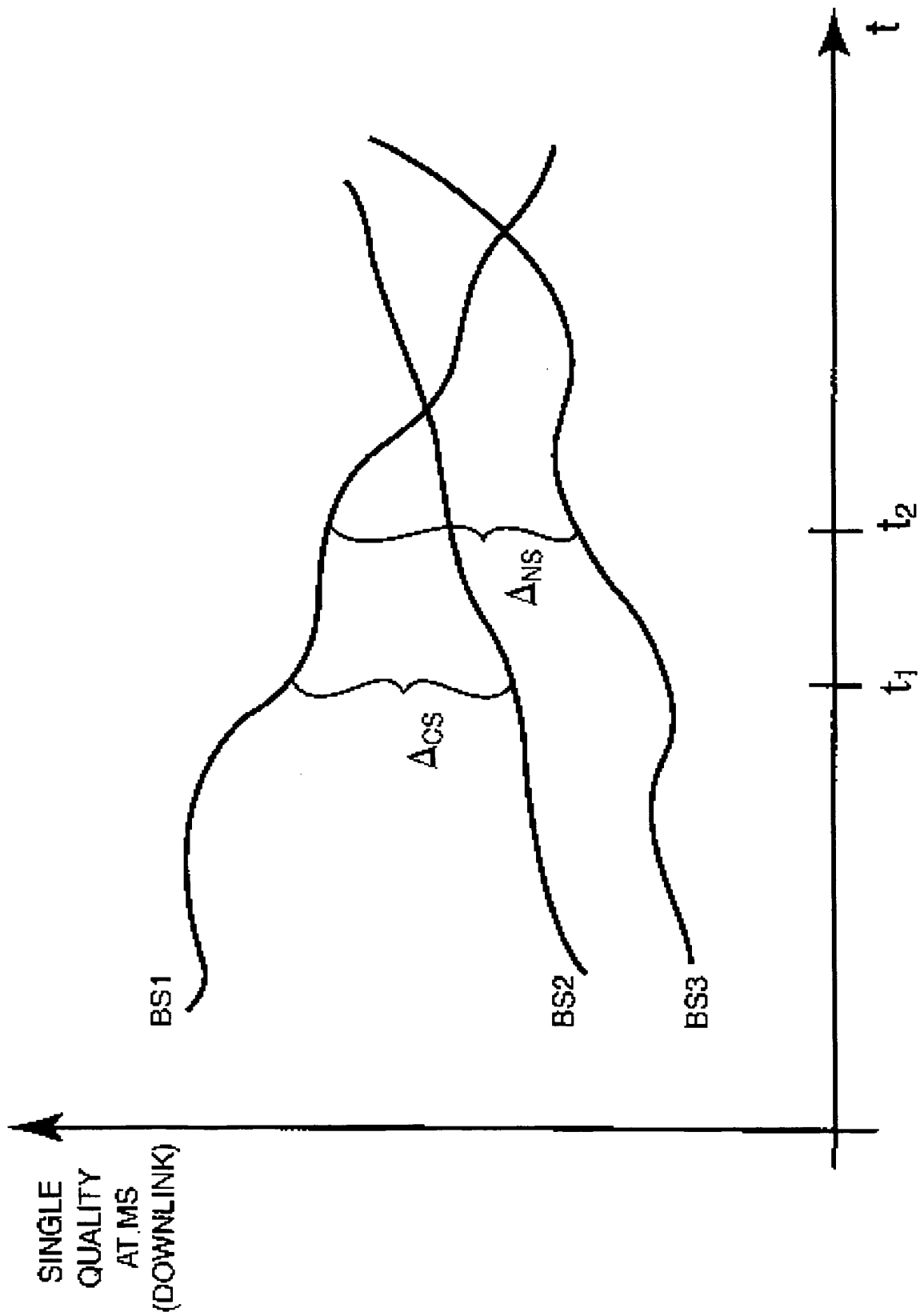


Fig. 7

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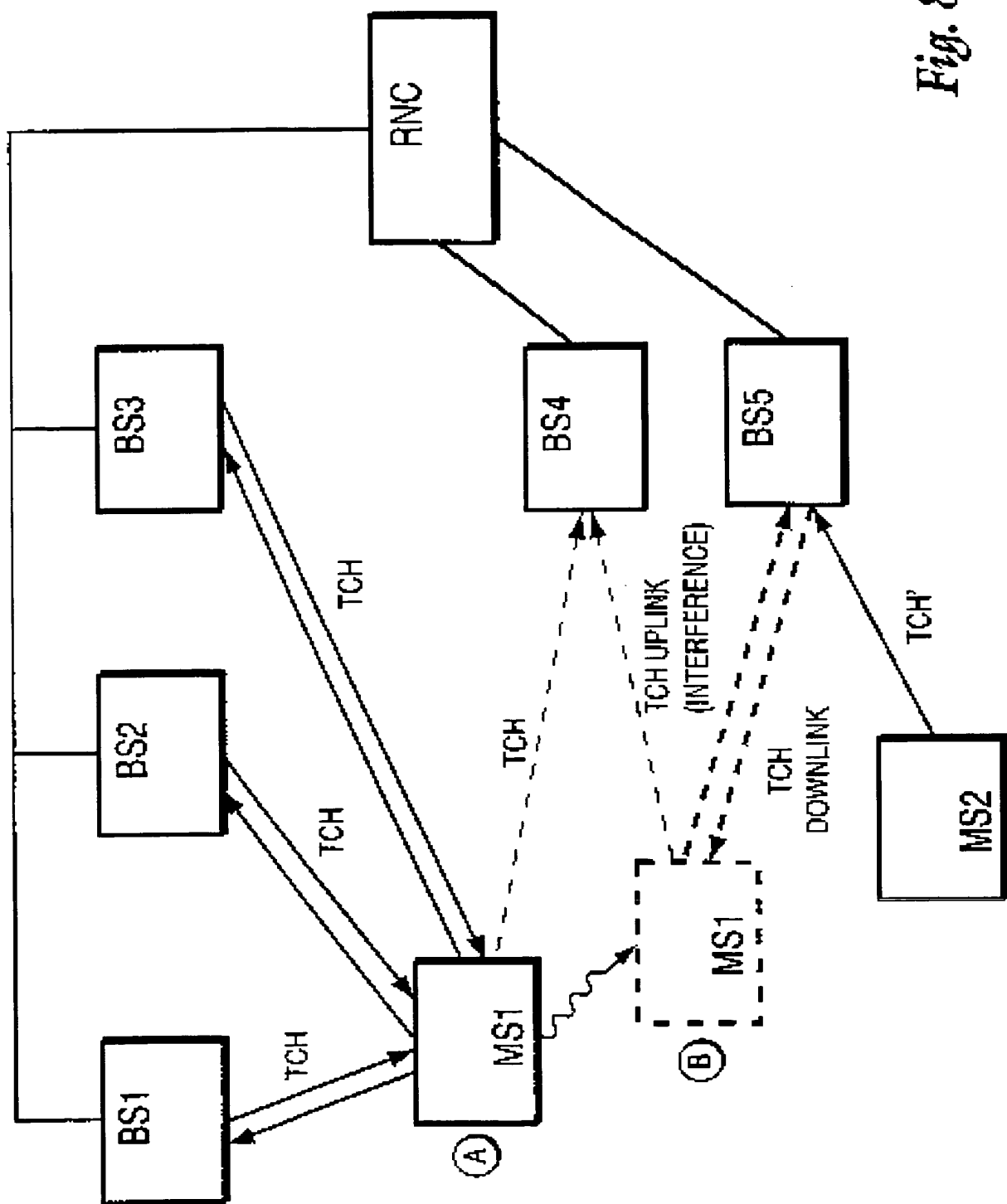


Fig. 8

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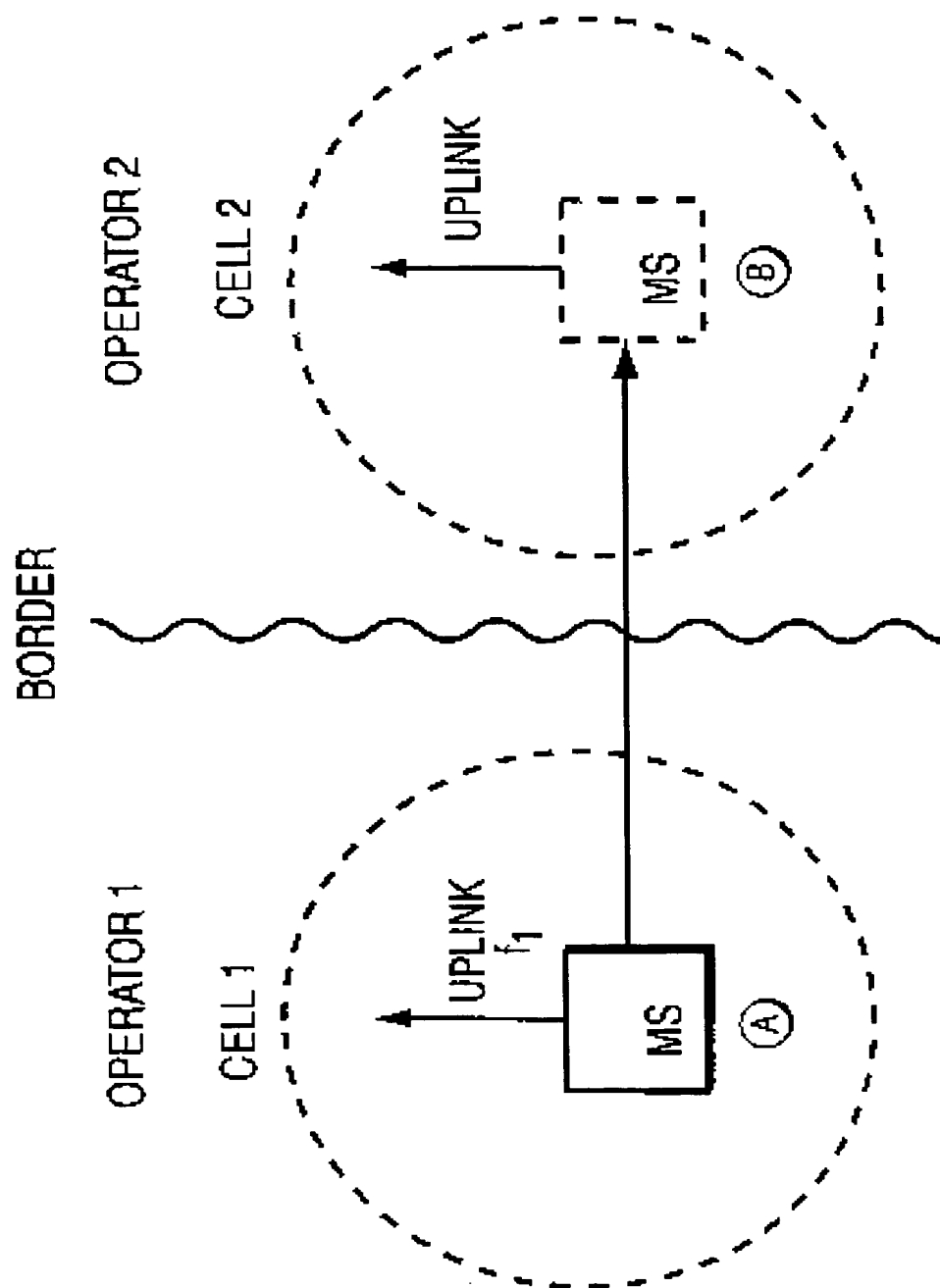


Fig. 9